

**DISCUSSION**  
**Introduction**  
The Stellwagen Bank National Marine Sanctuary Mapping Project is a cooperative effort of the U.S. Geological Survey and the National Oceanic and Atmospheric Administration, with support from the University of New Brunswick and the Canadian Hydrographic Service. The multibeam echo sounder survey was conducted on four cruises over a two-year period from the fall of 1994 to the fall of 1996. This map shows one of a series of 18 quadrangle sea floor maps in which sea floor depth information is depicted in sun-illuminated (for shaded relief) view at a scale of 1:25,000, with topographic contours superimposed in blue. The image shows here uses a sun elevation angle of 45 degrees above the horizon from an azimuth of 250 degrees and a vertical exaggeration of four times. In effect, topographic relief is enhanced by having the sun illuminate the sea floor from a position 10 degrees west of north, so that shadows are cast on the southern flanks of seabed features. Some features in the images are artifacts of data collection. They are especially noticeable where the seabed is smooth, and they include small high and low and nonvertical-looking features and patterns that are oriented parallel or perpendicular to survey tracklines. For a depiction of the topographic contours alone, and for an explanation of survey and topographic data-processing methods, see the companion map by Valentine and others (1997). Topographic contour maps of all 18 quadrangles in the map series are available as a CD-ROM in EPS, PS, Arc export, and PDF file formats (Valentine and others, 1998). Blank areas represent places where no data exists.

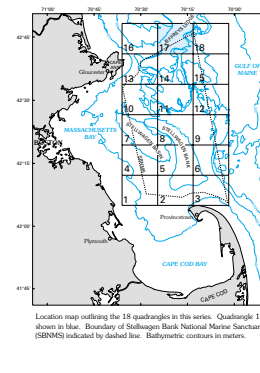
**Regional seabed features**  
The major topographic features depicted in the map series were formed by glacial processes. In broad terms, these features are interpreted here to represent a glacial history that developed in several stages. Ice containing rock debris moved across the region, sculpting its surface and depositing sediment to form the large basins, banks, ridges, and valleys. Many other features observed here represent the later stages of deglaciation. They are the result of processes at work when much of the area was covered by stationary retreating ice; and when at the same time small valley glaciers and ice falls were active in and near areas of high topographic relief. The sea included the region formerly occupied by ice, and seabed features were partly eroded and some new sedimentary deposits were formed. Today, the sea floor is modified mainly by strong southwesterward-flowing bottom currents caused by storm winds from the northeast. These currents erode sediments from the shallow banks and transport them into the basins. With time, the banks affected by these currents become coarser,

as sand and mud are removed and gravel remains; and the western flanks of the basins, and in some adjacent basins, are built up by deposits of mud and sand.

**Quadrangle 17 features**  
This quadrangle is bisected by a broad, northeast-trending bank, Jeffreys Ledge, that lies at a water depth of 35 to 65 m. The bank's surface is primarily gravel and includes numerous boulder piles and ridges. Boulder ridges oriented northeastward, parallel to the trend of the bank, are located mainly along the western side of the bank. They resemble and numerous deposits of rock debris piled up at the forward edge of glacial ice. Boulder ridges that trend southward, across the bank, resemble eskers (sand and gravel deposited by running water in channels within stationary glacial ice). The bank's western margin is a well-defined scarp (25 to 35 m of relief) that extends from 55 m to 90 m water depth in the north and from 50 m to 75 m water depth in the south. This margin is covered with sand, and it separates the bank from a basin to the west that is of variable depth and seabed type. The basin is subdivided by a ridge that extends west-northward from the bank to the northwest corner of the quadrangle. The ridge has a relief of 15 to 25 m and its surface lies at water depths of 75 to 80 m. It is covered with gravel, including boulder piles and ridges, and the gravel is covered in places with a veneer of sand. The ridge is bounded on the north and south by the deep parts of the basin (100–110 m), where the seabed is sandy mud. The basin shallow to the south along the western edge of the quadrangle water depths decrease from 100 m to 75 m. The basin floor here exhibits scattered small hills of gravel, covered in part with a veneer of sand, that are separated by a relatively smooth sea floor of muddy sand. The eastern margin of Jeffreys Ledge, south of approximately 42°44' N, is covered with sand intermixed with shell accumulations. North of here, the eastern margin of the bank is covered mainly with gravel except for a narrow band of sand (42°47.5' N, 70°14' W) that extends northeastward from a hill located at 42°46.5' N, 70°14.4' W. This hill has a relief of 25 m (30 to 55 m water depth). It is the more easterly and larger of a pair of distinctive conical hills that are outcrops of bedrock surrounded by sand and gravel of the bank surface. Approximately 27 km eastward of these two hills, a larger, conical hill is present along the eastern margin of the quadrangle (42°45.4' N). This hill also is a bedrock outcrop. It has a maximum relief of 100 m from the 35-meter summit, just east of the map area, to 135 m and lies mostly in the adjacent Quadrangle 18 to the east (Valentine and others, 2003b). The flanks and base of the hill are covered with coarse sandy and gravelly sediments. The area east of Jeffreys Ledge and south of the large conical hill is topographically complex. Two relatively deep basins are separated by a broad bank that extends southward from Jeffreys Ledge through water depths of 70 to 85 m. Along the

bank's northeastern margin is an apron of coarse sand (at depths of 65 to 75 m) that was transported from Jeffreys Ledge. The bank surface exhibits low, rounded hills and small, shallow basins. The hills are covered with gravel, including boulder piles. The gravel is covered in places with a thin veneer of sand that is most extensive on the hillside; the sand also predominates in the shallow basins. Somewhat deeper basins and valleys on the southern margin of this bank are covered with muddy sand. Much of the bank surface is characterized by long, narrow grooves in the seabed that typically are 50 to 100 m wide and less than 5 m deep. They are interpreted to be marks made by the jagged bottoms of icebergs that gouged the seabed by grinding here during the last stages of the last glaciation. These grooves are shallow and less pronounced than similar features that occur in Quadrangles 15 and 18 (Valentine and others, 2003a,b), possibly because they may have been partly filled by sand transported from the large bank that lies to the northwest (Jeffreys Ledge). The two deep basins that are bounded on their western sides by Jeffreys Ledge deepen eastward and are floored by muddy sand. The southern basin ranges in depth from 70 to 145 m, and the northern basin ranges in depth from 70 to 135 m. At the base of Jeffreys Ledge, narrow, low ridges that parallel topography extend along the western margins of both basins (42°42.05' N, 70°20.05' W and 42°45.8' N, 70°15.3' W). These ridges are interpreted to be lateral moraine deposits of rock debris piled up at the edge of moving ice) now covered with sand transported from the bank.

**REFERENCES CITED**  
Valentine, P.C., Baker, J.L., Unger, T.S., and Roworth, E.T., 1997, Sea floor topography of Quadrangle 17 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 97-230, scale 1:25,000.  
Valentine, P.C., Baker, J.L., Unger, T.S., and Polton, C., 1998, Sea floor topographic map and perspective-view imagery of Quadrangles 1-18, Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Open-File Report 98-135, 1 CD-ROM, scale 1:25,000.  
Valentine, P.C., Baker, J.L., and Unger, T.S., 2001a, Sun-illuminated sea floor topography of Quadrangle 15 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2715, scale 1:25,000.  
Valentine, P.C., Unger, T.S., and Baker, J.L., 2003b, Sun-illuminated sea floor topography of Quadrangle 18 in the Stellwagen Bank National Marine Sanctuary off Boston, Massachusetts: U.S. Geological Survey Geologic Investigations Series Map I-2718, scale 1:25,000.



## SUN-ILLUMINATED SEA FLOOR TOPOGRAPHY OF QUADRANGLE 17 IN THE STELLWAGEN BANK NATIONAL MARINE SANCTUARY OFF BOSTON, MASSACHUSETTS

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.  
For sale by U.S. Geological Survey, Information Services,  
Box 242086, Federal Center, Denver, CO 80225  
For more information contact:  
Paul Valentine, U.S. Geological Survey,  
384 Woods Hole Road, Woods Hole, MA 02543

By  
Page C. Valentine, Jessica L. Baker, and Tanya S. Unger  
2001